ATRC
ARIZONA TRANSPORTATION RESEARCH CENTER

RESEARCH NOTES:

Project 537 February 2006

Crash Data Collection and Analysis System

The Arizona Department of Transportation (ADOT) is responsible for the safety and operational efficiency of Arizona's state highways. Fulfilling that responsibility requires extensive data collection and analysis, which are labor-intensive and resource-intensive. Seeking to identify ways the agency could accomplish the greatest service improvements with the most efficient use of funds, ADOT engaged ARCADIS to perform a Crash Data Collection and Analysis study and examine the possibilities offered by technological innovations such as Electronic Data Entry (EDE), Relational Database Management Systems (RDBMS), and Geographic Information Systems (GIS). The study resulted in a comprehensive report with three components: an examination of best practices in use in the United States today, a use case and gap analysis examining ADOT's current data work, and a technical memorandum outlining how changes could be implemented. Together, the three parts point to a path to introduce best practices in ADOT's crash-data analysis related database systems. Adopting the practices outlined below can reduce the resources required to maintain these systems, freeing those resources to other safety-related concerns.

BEST PRACTICES

To identify the states whose system components can be considered best practices ARCADIS conducted a survey. Based on the survey results, leading states were selected for more in-depth analysis. The research team examined five components of each selected state's crash-data analysis system: data collection, data storage, analysis and reporting, accessibility, and overall system efficiency. The best innovations within each component were then combined to form an ideal system that would maximize efficiencies for any crash-data system, including ADOT's.

Some states have proven that electronic, field-based data entry and electronic data transfer (EDT) can expedite data entry and increase efficiency. Reducing data entry points and electronically transferring data increase data consistency and accuracy through the use of data element standards and business rules for validation and quality assurance/quality control (QA/QC). The use of an open RDBMS provides great flexibility in data accessibility and analysis. Direct links to outside databases such as facility, citation, drivers' license, and vehicle registration databases are beneficial.

The ideal configuration of analysis and reporting components varies with needs, but ADOT should target specific functions and capabilities. Among them:

- The ability to generate custom reports and queries from a centralized location that optimizes efficiency for end-users and managers.

- User-friendly GIS capabilities that integrate mapping and spatial analysis into reports.

- Easy access to and downloading of previously generated reports.

- The ability to perform advanced statistical analysis and charting by pulling data directly from the enterprise database to ensure that the most current information is used.

- A Web-based application for data retrieval and analysis that provides the greatest data access to the most users.

USE CASE AND GAP ANALYSIS

A use case study is a multi-level research that identifies current desires, assets, capabilities, and workflows for a particular organization. A gap analysis discovers where the current system falls short of best practices. Among the conclusions:

- Arizona should utilize electronic, field-based data entry and electronic data transfer. Those processes should use domains and business attribute rules for automated QA/QC and standardization of data elements. X,Y coordinates of accident locations should be determined and recorded from the Global Positioning System (GPS) or Geographic Information Systems (GIS) with every incident record to improve accident positional accuracy. External database systems, such as vehicle registration and driver's license databases, should be integrated into an enterprise system of transportation-related databases to minimize data entry. Personnel at crash scenes should collect more Model Minimum Uniform Crash Criteria (MMUCC) data elements, including harmful events[1]. The user community should standardize data elements for street naming and crash definitions. Signalized intersection and road contract release dates[2] should be collected and maintained.

- Arizona should integrate additional data sources to the Accident Location Identification Surveillance System (ALISS). The State Highway Log (SHL) system should be the primary source of facility information that is attached to the incident record, allowing statewide average of incidents to be calculated by facility. The current ALISS lacks detailed system documentation and the ability to manipulate the database structure as well as a visual data entry form to accommodate any changes in the future.

- Arizona should automate its data reporting and data exporting routines, giving users direct access to a live crash-data analysis system and allowing them to analyze the data and generate custom reports for export. On-line functions should include GIS, advanced statistical analysis, and graphic and charting capabilities. This on-line access point should be built as a one-stop access point for data and analysis and should include access to digital ALISS reports. The system should also be designed to automatically submit data to the Federal Highway Administration (FHWA) and Fatality Analysis Reporting System (FARS). It should allow users to:
    - generate statewide averages of accidents by facility type.
    - generate lists of top ten accident locations for a given area by facility type.
    - identify high-risk/hazardous locations.
    - assess the effectiveness of improvements
    - calculate accident and severity rates over identified stretches of highway
    - draw diagrams using Intersections Magic.

  Basic and user-friendly GIS diagramming and mapping should also be functional.

- Arizona should grant access to its crash-data analysis system to all users within the crash data community through an Internet-based application and a one-stop portal for data access and analysis. A 24/7 solution would provide the greatest access and flexibility for end users.

- Arizona needs to eliminate redundant data entry. On-line and customizable data downloads, centralized access to tools and data, and live

---

[1] Harmful events are defined as a series of related incidents within an accident or a crash. For example, in a car crash one car rear-ends another car and the struck car then runs into a third car. Then, this car crash will have two harmful events, the first involves the first and second cars and the second involves the second and third cars. First, second, third harmful events and so on indicate the order of the incidents that occur within an accident. Of all the harmful events involved in an accident, most harmful event is the most severe incident that causes the most damage or injury.

[2] A Contract Release Date is the official date on which a highway agency takes control of the road or intersections maintenance from a construction contractor and open the road for traffic.

linkages for custom reporting will minimize staff intervention at all levels.

A use case study delves into the specifics of an organization, resulting in a broad and complete understanding of its business practices. For the ADOT study, a combination of interviews and data analysis defined current assets and capabilities. ARCADIS visited ADOT's facilities and interviewed several key players responsible for crash data, as well as people at external entities such as the Federal Highway Administration (FHWA), regional governments, and local municipalities.

Three areas were identified as critical for appropriately defining ADOT's business practices. These were internal desires, existing assets and capabilities, and workflows. The internal desires section of this report identifies the current desires expressed by the various users of ADOT's systems and data. The desires are apportioned among the five components used to identify best practices: data collection, data storage, analysis and reporting, accessibility, and overall efficiency. The existing assets and capabilities section gives an overview of ADOT's current systems, databases, GIS capabilities, analytical tools, reporting tools, and data-sharing. The workflows identify data flow and timeframes for getting these data to and from ADOT systems.

TECHNICAL MEMORANDUM

The technical memorandum of this report proposes solutions to the desires and gaps identified during the earlier portions of the study. It lays out specific course of action to reduce the resources ADOT must allocate to collect and analyze crash data. The strategy aims at delivering the most capability for the least funding while building toward an ideal crash data collection and analysis system.

Step 1 – Creation of a new ALISS database

To accomplish the goals set forth in the previous portions of the study, a new database system must be devised to store and retrieve incident records. Generating accident and severity rates, analyzing safety improvement effectiveness, and prioritizing accident locations by facility type all require linking the ALISS and ADOT Information Data Warehouse (AIDW) databases. Unfortunately, the current ALISS is neither documented nor customizable, making it difficult to establish this linkage. Either funding needs to be applied to the ALISS to document it and make it customizable, or a new system needs to be developed. The project team recommends creating a new ALISS based upon a GIS system and using an RDBMS and ArcSDE. This will provide the basis for a relationship between the AIDW and the ALISS while utilizing software capabilities already in place within ADOT. The new ALISS will need a new interface for data entry and minimal training for current data-entry staff. Once the database is created, the records in the current ALISS must be migrated to the new system.

The new system should take advantage of MMUCC standards for data elements with the understanding that not all elements are currently collected in the field. As more agencies move toward electronic data entry, the ability to collect additional MMUCC elements may become available. The database should be designed to incorporate this possibility. The data elements of first, second, and most harmful events should also be incorporated. This change will require an alteration of the accident data collection form.

The existing stored reports in the current ALISS will need to be migrated to the new system. These reports are very important to the crash data community as a whole, and the system would be taking a step backward if they were lost in the conversion.

Step 2 – Integrate the new ALISS with the current GIS infrastructure and the data warehouse

ADOT GIS is undergoing a migration to a new geodatabase data structure for maintaining roadway information. This system is linear-referenced with dynamic segmentation and is capable of storing a variety of facility information in the relational database scheme. The project team recommends integrating the ALISS with the new GIS roadway database and the AIDW. This will provide all facility information in a GIS format that can be analyzed with the new ALISS.

Steps one and two are the most important aspects of this implementation plan and should be performed concurrently to maximize interoperability and minimize cost.

Step 3 – Create Electronic Data Transfer (EDT) routines

ADOT is duplicating a significant amount of effort by not accepting electronic transfer of incident records. Several municipalities type incident records into a database system in their offices, only to then send a hard copy to ADOT for entry into the ALISS. The project team recommends that ADOT accept EDT and create import routines and workflows to support this initiative. This will involve a study to determine all the possible data import formats in the systems that the various agencies use for their incident records. The team believes that there are probably only five or six different systems in use and the creation of the import routines should only require minimal effort. Each record should contain the same data elements, minimizing the complexity of creating the import routines.

Step 4 – Create web access to integrated databases for data query and download

Staff resources are required to distribute ALISS data to users both within ADOT and externally. This can be eliminated by utilizing existing software within ADOT GIS. ArcIMS is a Web-based application that allows display, query, and download of GIS data through the Internet at a user's discretion. When the ALISS is integrated with the AIDW and the ADOT GIS database, users can access data through the ArcIMS Website. Basic GIS functionality is inherently available to all users who have access to the Website. This will also provide live access to the ALISS, ensuring that users get up-to-date information for their analyses. ArcIMS can be designed to only display and export information that is not sensitive, or a security system can be implemented to grant or deny users access to sensitive data.

Step 5 – Accident and severity rates database

With the linkage among the ALISS, AIDW, and GIS databases, accident and severity rates can be calculated for facility types by numerous factors, including vehicle type, driver's age and gender, weather condition, and geography. These rates should be incorporated into a database for all to use. This database can be created without staff involvement other than routine database administration. Once the database is built, updating the rate values can be automated. These calculations are relatively simple within a GIS system and can be provided through the ArcIMS Website with minimal effort. A study should be undertaken to decide which rate calculations will be made available, including rates by time and geography (i.e. weekly, monthly, yearly by county, ZIP code, region, by facility, type, age, weather, etc.). The study will drive the database design, the number of execution statements required, and the frequency of the rate updates. The rates will then be tied to the appropriate highway GIS features for inclusion into the overall system for users to analyze. This database feasibility is currently being researched by the Maricopa Association of Governments (MAG) and its progress should be monitored.

Step 6 – Additional data collection efforts

All analytical capabilities start with good data resources. The collection of data about signalized intersections, contract release dates, and safety improvements would grant users analytical capabilities that they currently do not have. Most of these data should already be maintained by various agencies, including ADOT, and need only to be found and integrated into the GIS system. Some of these data demand more resource to be integrated than others, but the level of effort deeded for the data integration cannot be quantified until the data resources can be found and analyzed.

Step 7 – Electronic data entry

It would be optimal for the state to embrace electronic data entry for all incident records. This may not be feasible due to financial limitations, but ADOT should promote its use whenever possible in the hopes that eventually this will become a reality.

The full report: *Crash Data Collection and Analysis System* by Ed Cherry, Rob Floyd, Tyson Graves, Steve Martin and David Ward, ARCADIS, 13777 Ballanytine Corporate Place, Suite 250, Charlotte, NC 28277 (Arizona Department of Transportation, report number FHWA-AZ-06-537, published February 2006) is available on the Internet. Educational and governmental agencies may order print copies from the Arizona Transportation Research Center, 206 S. 17th Ave., MD 075R, Phoenix, AZ 85007; FAX 602-712-3400. Businesses may order copies through ADOT's Engineering Records Section.